REMARKS

The present Response does not amend, add, or cancel any claims. Accordingly, claims 6-12 remain pending in the application. Claims 6, 8, and 9 are independent.

In the Office Action of September 22, 2009, claims 6-12 were rejected under 35 USC §103(a) as being unpatentable over U.S. Patent No. 5,902,243 issued to Holley et al. ("Holley") in view of U.S. Patent No. 6,497,665 issued to Hunt et al. ("Hunt"). This rejection is respectfully traversed.

In rejecting the claims, the Office Action alleges that Holley discloses an ultrasonic imaging system that includes a conventional ultrasound transmit beamformer for supplying transmit pulses that are applied via a transmit/receive switch to a multi-element transducer array for transmitting ultrasound pulses into a region of an imaging subject. The reflected ultrasound pulses are received by the transducer array and applied to a conventional ultrasound beamformer via the transmit/receive switch. The receive beamformer is indicated as outputting an analytic signal to a line buffer that is coupled to a summer which subsequently sums two successive ultrasound lines. The output of the summer is allegedly sent to an image processor for further processing and display to the user. The Office Action further indicates that Holley discloses shifting the phase of the transmit pulses of various harmonic components.

The Office Action admits that Holley fails to disclose introduction of a microbubble contrast agent into the living body and supplying a signal indicative of spatial distribution of the microbubbles. However, the Office Action indicates that the system of Holley is capable of operating with or without the use of added contrast agents in both contrast and tissue harmonic imaging. Hunt is relied upon for

disclosing contrast agent microbubbles that resonate and emit harmonics of the transmitted frequency so that a display can be configured to receive a non-linear response and create an image of the insonified contrast agent and surrounding tissue. The Office Action indicates that the magnitude of Hunt's microbubble harmonics depends on the magnitude of the excitation signal pulse. Additionally, Hunt is indicated as suppressing tissue signal responses of the fundamental frequency of a significant magnitude so that non-linear responses from a contrast image can be detected. The Office Action concludes that it would have been obvious to combine the teachings of Holley and Hunt for the purpose of increasing visualization, thereby arriving at the claimed invention. Applicants respectfully disagree.

Independent claim 6 defines an ultrasonic imaging device for transmitting/receiving ultrasonic pulse to/from a living body in which microbubbles for contrast are introduced, and forming a contrast image of the inside of the living body. The ultrasonic imaging device includes a transmit beamformer for generating a transmit pulse, and a receive beamformer for generating time-series reception echo signals, to each of which a delay time is given for generating receiving sensitivity having directivity. An adder is provided for summing the time-series reception echo signals, while a transmit/receive sequence controller controls the transmit beamformer and the receive beamformer. According to independent claim 6, the transmit/receive sequence controller controls the transmit beamformer and the receive beamformer to perform transmitting/receiving operations N times, where N is an integer greater than or equal to 3. This is done by controlling a sampling frequency of the transmit pulse being an integer-multiple of N with respect to a maximum frequency of frequency components of the transmit pulse, and N pieces of

transmission pulse waves having a common envelope signal and different waveforms under a transmission/reception wave focus condition, and controlling carrier waves of the transmission pulse waves so as to vary in phase by 360°/N from one wave to a next wave, and receiving returned ultrasonic waves as N pieces of the time-series reception echo signals. Furthermore, the adder sums the N pieces of time-series reception echo signals and outputs a signal indicative of a spatial distribution of the microbubbles. At least one benefit achieved by the imaging device of independent claim 6 is an ability to resolve non-linear problems associated with the transmit amplifier, because the sampling frequency of the transmit pulse is set to an integer multiple of N with respect to a maximum frequency of components in the transmit pulse.

More particularly, the present invention makes it becomes possible to suppress transmission/reception sensitivity to components from the fundamental wave to the harmonic wave of the ultrasonic echo signal from the soft tissue in the living body. When N is an integer = 3, for example, each of the phase differences is 120 degrees. Since the phase of the second harmonic wave is double that of the phase of the fundamental wave, the phases of the fundamental wave and the second harmonic wave from the living body becomes zero when the phase of the carrier wave is zero. When the phase of the carrier wave is 120 degrees, the phase of the fundamental wave becomes 120 degree, but the second harmonic wave is generated at 240 degrees. Finally, when the phase of the carrier wave is 240 degree, the phase of the fundamental is 240 degrees, but the second harmonic wave has a phase of 120 degrees. Thus, if the 3 pieces of time-series reception echo signals are summed, the result becomes zero. Accordingly, it becomes possible to

suppress the fundamental wave to the (N-1) harmonic component from the living body.

The phase of the echo signal generated by being scattered by the microbubble contrast medium, however, is influenced by the amplitude of the envelope due to its strong non-linear resonance characteristic. Furthermore, it does not have a predetermined relationship to the phase of the transmission signal carrier wave. As illustrated in Figs. 6(a) - 6(c), the echo signals scattered from the microbubbles have different waveforms and no constant relations to phases 0, 120, and -120 (240) degrees. Consequently, even if three echo signals obtained by performing the transmitting/receiving operation three times while varying the phase of the transmission pulse carrier wave by 120 degree are summed, the components which are not cancelled out will remain.

According to the present invention, however, the adder sums the N-series reception echo signal and supplies an output signal indicative of the spatial distribution of the microbubbles. Accordingly, it is possible to obtain an ultrasonic image in which the contrast medium is clearly distinguished from the soft tissue.

The Office Action alleges that the combination of Holley and Hunt discloses all of the features recited in independent claim 6. This does not appear to be the case. Holley discloses a method for performing ultrasound imaging wherein two (2) ultrasonic transmit pulses are initially transmitted into a region. The first components of the transmit pulses are inverted with respect to each other, and the second components are not. The received ultrasound pulses associated with the transmit pulses are summed so that they selectively cancel either the harmonic or fundamental components. Thus, by properly selecting the inverted and non-inverted portions of the transmit pulses, they can be made unipolar, or pre-distorted to further

reduce the second harmonic energy associated with the system or tissue non-linearities. Holley goes on to indicate that the summing operation can include summing of more than two (2) ultrasound signals of like polarity in order to selectively suppress fundamental components. Alternatively, the summing operation can be of ultrasound signals of opposite polarity in order to selectively suppress second harmonic components. See column 8, lines 15-20.

Hunt discloses a system for fundamental real-time imaging of non-linear response of tissue in which a contrast agent has been introduced. The tissue containing the contrast agent is excited by multiple excitation levels, and the ultrasound response at the fundamental frequency is detected for reproducing the image. According to Hunt, the ultrasonic irradiation is performed using a first and second amplifier. The projected response may be subtracted from the stored second response (step216), so that the linear responses are removed leaving the nonlinear responses from the contrast agent and the surrounding issue. See col. 2, lines 58-60, and col. 7, lines 43-52. As illustrated below, Hunt eliminates the fundamental component (f1) from the living body, but the second component is not eliminated.

Hunt requires a filter to eliminate the second harmonic component. If the second harmonic component is eliminated with a filter, however, the bandwidth of the signal becomes narrow and the part of the fundamental component of the microbubbles is also eliminated. Consequently, the spatial resolution is decreased. The combination of Holley and Hunt simply fails to provide any disclosure or suggestion for all the features recited in independent claim 6.

It is therefore respectfully submitted that independent claim 6 is allowable over the art of record.

Claim 7 depends from independent claim 6, and is therefore believed allowable for at least the reasons set forth above with respect to independent claim 6. In addition, this claim introduces novel elements that independently render it patentable over the art of record.

Independent claims 8 and 9 both define ultrasonic imaging devices that incorporate features similar to those recited in independent claim 6. Accordingly, the devices defined by independent claims 8 and 9 are capable of cancelling both the harmonic and fundamental components simultaneously. As previously discussed, the combination of Holley and Hunt fails to provide any disclosure or suggestion for simultaneously cancelling both the harmonic and fundamental components.

It is therefore respectfully submitted that independent claims 8 and 9 are allowable over the art of record.

Claims 10-12 depend from independent claim 9, and are therefore believed allowable for at least the reasons set forth above with respect to independent claim 9. In addition, these claims each introduce novel elements that independently render them patentable over the art of record.

For the reasons stated above, it is respectfully submitted that all of the pending claims are now in condition for allowance. Therefore, the issuance of a Notice of Allowance is believed in order, and courteously solicited.

If the Examiner believes that there are any matters which can be resolved by way of either a personal or telephone interview, the Examiner is invited to contact Applicants' undersigned attorney at the number indicated below.

AUTHORIZATION

Applicants request any shortage or excess in fees in connection with the filing of this paper, including extension of time fees, and for which no other form of payment is offered, be charged or credited to Deposit Account No. 01-2135 (Case: 520.46411X00).

Respectfully submitted,
ANTONELLI, TERRY, STOUT & KRAUS, LLP.

/Leonid D. Thenor/
Leonid D. Thenor
Registration No. 39,397

LDT/vvr
1300 N. Seventeenth Street
Suite 1800
Arlington, Virginia 22209
Tel: 703-312-6600
Fax: 703-312-6666

Dated: January 22, 2010